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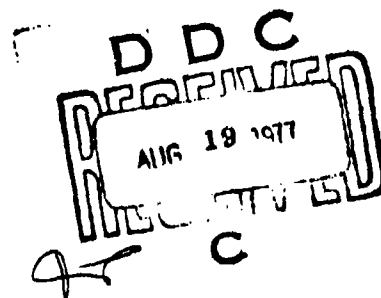
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Factors Influencing Simulator Training Effectiveness in the U.S. Air Force

by
Paul W. Caro

SEVILLE RESEARCH CORPORATION
400 Plaza Building
Pensacola, Florida 32505



HUMAN RESOURCES RESEARCH ORGANIZATION
300 North Washington Street • Alexandria, Virginia 22314

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FINAL REPORT:
FACTORS INFLUENCING SIMULATOR TRAINING EFFECTIVENESS
IN THE U.S. AIR FORCE

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Background

It has been noted for several years that military services tend to use aircraft simulators somewhat less extensively than do certain civilian organizations in achieving flight training goals. In commenting upon this situation, the Comptroller General of the United States stated the following:

"Although the military services have taken some steps to increase simulator development and use, there continues to be resistance to substitution of simulation for flying time. More emphasis on the use of simulators is required if flying time is to be reduced and if the services are to effectively use simulator technology."¹

The referenced report goes on to identify a number of factors, principally factors related to the management of simulator training and attitudes toward such training, which are believed to impede more extensive use of simulators. Factors identified include regulations which emphasize aircraft rather than simulator training, inadequate instructor training, failure to use simulator capabilities fully, and poor simulator maintenance. The influence of such factors upon trainer use has been documented elsewhere.² Additional factors related to the design of the simulators themselves and of the training programs in which the simulators are employed have been

¹Comptroller General of the United States. Department of Defense Use of Flight Simulators--Accomplishments, Problems, and Possible Savings. Washington, D.C.: GAO Code 952050, June 14, 1975.

²Smode, A.F., Hall, E.R., & Meyer, D.E. An Assessment of Research Relevant to Pilot Training. AMRL TR 66-196. Aerospace Medical Research Laboratories, Wright-Patterson AFB, Ohio, 1966.

identified as factors which impede simulator use in other reports.^{1,2} Still other factors influence the acceptance of such devices³ and may indirectly impede their use.

It is possible, however, to use simulators extensively while at the same time to use them ineffectively. In one study of Army devices, for example, it was found that the extensive use of a particular device added cost, but no training value, to an already expensive pilot training program.⁴ Clearly, the intent of all simulator users is to achieve effective training rather than merely to use training equipment. Studies of trainer use, such as those cited here, tend to make the tacit assumption that users of simulators will assure that the devices are used effectively, but such is not always the case. Effective use of simulators is critical, however, if the OSD-announced goal of a 25% reduction in flight training by 1980 is to be achieved.

Because of its extensive investment in simulators and its reliance upon these devices for significant portions of the training of its aircrews, the Air Force is especially aware of the need for simulator training to be of maximum possible effectiveness. Toward that end, the Human Resources Laboratory at Williams Air Force Base has devoted major efforts and resources to research into simulator design and utilization factors, and major Air Force simulator users, such as the Tactical Air Command, have established projects and project offices to evaluate the effectiveness of ongoing

¹Meyer, D.E., Flexman, R.E., Van Gundy, E.A., Killian, D.C., & Lanahan, C.J. A Study of Simulator Capabilities in an Operational Training Program. AMRL TR 67-14. Aerospace Medical Research Laboratories, Wright-Patterson AFB, Ohio, 1967.

²Hall, E.R., Parker, J.R., Jr., & Meyer, D.E. A Study of Air Force Flight Simulator Programs. AMRL TR 67-111. Aerospace Medical Research Laboratories, Wright-Patterson AFB, Ohio, 1967.

³Mackie, R.R., Kelley, G.R., Moe, G.L., & Mecherikoff, M. Factors Leading to the Acceptance or Rejection of Training Devices. NAVTRAEQUIPCEN 70-C-0276-1. Human Factors Research, Inc., Goleta, Calif., 1972.

⁴Jolley, O.B., & Caro, P.W., Jr. A Determination of Selected Costs of Flight and Synthetic Flight Training. Technical Report 70-6. Human Resources Research Organization, Alexandria, Va., 1970.

simulator training programs. While reliable data are not immediately available, it is believed that major savings in dollars and fuel could result from even relatively small increases in the effectiveness of current simulator training programs in the Air Force.

Interest in the effective use of simulators is not limited to the Department of Defense and its pilot training agencies. For example, the Principal Investigator for the project reported herein was asked by the Royal Aeronautical Society (RAS) to prepare a paper on the subject of simulator training effectiveness. The title of the paper is "Some Factors Influencing Transfer of Simulator Training," and its content discusses information derived from a survey of the research and training literature and from the author's experience related to influences upon simulator training effectiveness. An objective in the preparation of the paper was to systematize the available information so that it could be more readily used to identify factors which impede the effectiveness of simulator training, and thus enable operational personnel to increase simulator training effectiveness through the appropriate manipulation of those factors.

The RAS paper did not treat the subject as comprehensively as might be desired, however. Its preparation was constrained in two ways: (1) a limit of 18 pages in length was imposed by the Society; and (2) the budget under which the paper was prepared did not permit full treatment of the topics or investigation of ongoing simulator training programs in order to identify additional factors which were influencing the effectiveness of current simulator training programs. The literature survey did not exhaust the available sources, and several topics which were identified as relevant to the survey could not be included because of the space limitation. A more thorough treatment was considered desirable of factors influencing simulator training effectiveness and of the manner in which simulator training effectiveness is determined, the latter topic being a secondary subject discussed in the RAS paper.

The project summarized in this Final Report consisted of efforts to expand the RAS paper beyond its original limited scope, and to include material about the effectiveness of Air Force simulator training. Specific interest was expressed by Air Force personnel with whom the original paper was discussed in determining the extent to which the effectiveness of Air

Force simulator training might be increased through modified utilization practices and in identifying needs for research which could lead to more effective simulator training. The present project was in part a response to these expressed interests with respect to expanding the scope of the paper and making it more relevant to Air Force simulator training per se, as well as to identifying needs for increased simulator training wherever possible.

Approach

The conduct of the research consisted of three principal activities: (1) literature surveys; (2) visits to selected Air Force simulator training facilities; and (3) reporting. In general, the literature survey was conducted before the visits were made to Air Force facilities, although there was some temporal overlap in these two activities.

Literature Survey. The literature surveys concentrated upon the HumRRO Pensacola Office Technical Library. Because of previous HumRRO studies of flight training and simulation, this library had good coverage of the subject area of concern in the present study. As information relevant to the objectives of the research was found during the literature survey, it was integrated with information contained in the RAS paper. In addition, information gathered during the visits to ongoing simulator training activities pertinent to the literature being reviewed was incorporated into the revision of the RAS paper as appropriate.

Visits to Simulator Training Facilities. In order to gather information concerning Air Force simulator effectiveness, visits were made to ten simulator training activities at nine Air Force bases. During these visits, ongoing simulator training programs were observed, and interviews were conducted with a sample of the instructors, students, and training program administrative or supervisory personnel associated with such training. The purpose of the observations and interviews was to secure information to include in the project reports.

Prior to visiting Air Force simulator training facilities, interview guides were prepared. These guides served as checklists to assure that the time spent at each simulator training facility was productive. The guides addressed the available data concerning the effectiveness of the

simulator training under study and the manner in which those data were obtained; the possible influence of factors which the literature survey suggested are important upon the simulator training being conducted; and factors which were perceived as influential by the researcher and/or by local training and supervisory personnel but were not identified during the literature survey.

Table 1 identifies the Air Force bases visited during this research and the simulators involved in the training activities investigated at each. These bases and simulators were selected to represent Air Force simulator training activities beyond the Undergraduate Pilot Training (UPT) level. UPT simulator training activities were not investigated during the present research because the nature of UPT simulator training is expected to undergo significant change in the near future with the introduction of new simulators currently being procured for that program.

TABLE 1. SIMULATOR TRAINING PROGRAMS SURVEYED

Air Force Commands	<u>Combat Crew Training</u>		<u>Continuation Training</u>	
	Aircraft	Location	Aircraft	Location
ADCOM	F-106	Tyndall AFB	F-106	Castle AFB
MAC	C-5	Altus AFB	C-5	Travis AFB
SAC	B-52	Carswell AFB	B-52	Castle AFB
	FB-111	Plattsburgh AFB		
TAC	F-4	Luke AFB	F-4	Eglin AFB
	A-7	Davis-Monthan AFB		

The simulator training programs included in the survey were selected to be representative of Air Force aircraft and mission types. Both Combat Crew Training (CCT) and Continuation Training (CT) simulator programs were surveyed for the Aerospace Defense Command (ADCOM), the Military Airlift Command (MAC), the Strategic Air Command (SAC), and the Tactical Air

Command (TAC). For each command, the same simulators/aircraft were surveyed with respect to both CCT and CT, e.g., the MAC portion of the survey concentrated upon the C-5 aircraft for both CCT and CT activities. In the cases of SAC and TAC, the survey of CCT activities included an additional aircraft not included in the surveys of CT activities. This was done because of the large differences in aircraft configuration and crewing assignments, compared with the other aircraft surveyed, and the additional aircraft represented (i.e., the two-place FB-111 for SAC and the single-place A-7 for TAC). It was thought that including these additional aircraft might yield data of interest to the purposes of this project which would not apply to the other aircraft included in the survey. Thus, the survey examined six CCT and four CT programs of the four commands located at nine Air Force bases. Six different aircraft were simulated by the devices examined during the survey. For several of these aircraft, different models of the same aircraft were represented by these simulators, e.g., the B-52D and the B-52G.

In addition to the interviews conducted at the locations identified in Table 1, the simulators themselves were examined, and Air Force documents describing the devices and the manner of their use were reviewed. Particular attention was directed to seeking documented evidence of simulator training effectiveness at each location. Where no documented evidence of the effectiveness of simulator training could be found, personnel responsible for the conduct of such training were questioned extensively in an attempt to determine the perceived value, quantitative or otherwise, of such training and the bases for their perceptions. As was stated earlier, no attempts were made to conduct experimental studies to determine the effectiveness of simulator training activities.

Reporting. The results of the research program were presented in a Technical Report entitled, Some Factors Influencing Air Force Simulator Training Effectiveness, March, 1977. The report describes the project activities leading to preparation of the research report in more detail than is contained in the present Final Report.

Findings and Recommendations

The principal findings and recommendations of the research project are summarized below:

Findings. Ten simulator training effectiveness study designs that have been used in studies of simulator training effectiveness were identified and described in terms of simple models. The descriptions of these models include information concerning the relative value of each with respect to the relevance and objectivity of the data it yields. The efforts by the Air Force to validate the simulator training activities surveyed are described in relation to these ten study design models. It was found that the programs surveyed had not been subjected to formal evaluation studies that would establish their training effectiveness in quantitative terms. In those instances in which attempts had been made to validate simulator training, a tendency was noted to employ study models that were based upon subjective opinions rather than upon objective data collected during transfer of training studies.

A number of suspected or potential factors influencing simulator training effectiveness were identified during the project. These factors include simulator design for training, simulator visual display fidelity, simulator platform motion system fidelity, simulator handling characteristics, simulator training program features, simulator trainee and instructor characteristics, and attitudes and expectations toward simulator training. The discussion of each of these factors reviews relevant literature and Air Force simulator and training system design features and training practices.

The available information concerning the influence of these factors upon simulator training effectiveness was found to be quite limited. Because of the absence of objective studies validating Air Force simulator training effectiveness, the influence of factors identified during the survey upon such training could only be hypothesized. Additionally, definitive data could seldom be found in the literature reviewed that would permit the quantification of the influence of many suspected factors, and methodological problems made it difficult to generalize conclusions from the literature to the Air Force programs surveyed. Therefore, the information presented in this report regarding influences upon simulator training effectiveness in some instances is suggestive rather than conclusive.

Recommendations. Principal recommendations are as follows:

--Increased emphasis should be placed upon validating Air Force simulator

training activities, employing validation study design models that emphasize objective measurement of trainee performance in operational aircraft against predetermined performance standards.

--Research should be undertaken to examine simulator design considerations as a function of specified training objectives and of the manner in which the devices are to be used to achieve those objectives.

--Research should be undertaken to determine the cognitive and visual cues essential to the attainment of visual training objectives and to find means of attaining those objectives that do not rely exclusively upon extra-cockpit visual simulation.

--Research should be undertaken to examine separately the influences of maneuver and disturbance motion cues, with particular attention to an analysis of disturbance motion cues in relation to specific training objectives.

--Reviews of Air Force simulator training activities should be conducted to identify areas in which better use could be made of available information in the areas of human learning and performance.

--Increased emphasis should be placed upon the needs of individual trainees in the development and administration of simulator training programs.

--Research should be undertaken to identify the instructor skills and techniques needed for effective and efficient simulator training, and training programs in which such skills and techniques could be developed should be provided all simulator instructors.

--Existing administrative practices related to simulator training should be examined to assure that they are conducive to favorable attitudes toward simulator training and to the effectiveness of that training.

Other Project Activities

In addition to the principal project activity described above, the Principal Investigator made a presentation at the 38th Military Operations Research Society Symposium as a part of the research project. The presentation made use of information that had been developed during the surveys of Air Force simulator training activities described above, as well as information developed during previous research sponsored by the Army, Navy

and Coast Guard. A Technical Report, Some Current Problems in Simulator Design, Testing and Use, was prepared based upon the symposium presentation. That Technical Report is summarized below:

"This report is concerned with the general problem of the effectiveness of simulator training and reflects information developed during the conduct of aircraft simulator training research projects sponsored by the Air Force, Army, Navy, and Coast Guard. Problems are identified related to simulator design, testing and use that impact simulator training effectiveness. These problems are (1) isolation of the simulator user from the design and development process, (2) inattention to behavioral and training models during that process, (3) ignoring training considerations during simulator testing, (4) inadequate feedback to simulator designers concerning simulator training effectiveness, (5) inattention to techniques of simulator training that differ from techniques of aircraft training, (6) inadequate training for simulator instructors, (7) use of rate of simulator utilization as an index of its training effectiveness, and (8) inadequacies of simulator training cost effectiveness data."

In addition to the above, a paper was prepared and submitted to the Naval Training Equipment Center for presentation at the 10th NTEC/Industry Conference to be held in the fall of 1977. The paper, titled "Platform Motion and Simulator Training Effectiveness," is based upon information developed during the current research project related to the influence of motion cues upon the effectiveness of training in aircraft simulators. The paper is summarized below:

"Several recent studies reported that simulator motion did not benefit subsequent flight performance. Other studies have reported various effects of motion upon pilot performance in simulators. These possibly contradictory findings are examined in the light of recent distinctions made between maneuver and disturbance motion. The studies in which simulator motion did not benefit transfer predominantly employed maneuver motion cues, whereas the other group of studies incorporated more disturbance motion cues. Pilot reactions to simulator motion also were examined in terms of maneuver vs. disturbance motion, and it was noted that judgments of the training value of simulator motion were related to the maneuver-disturbance distinction. It is concluded that maneuver motion may be of little

potential training value, under many circumstances, and data necessary to an adequate simulation of disturbance motion may not be available. An analysis of the training requirements associated with disturbance motion is needed."

It should be noted that this paper has not yet been accepted by the Conference Program Committee.

List of Technical Reports Issued Under the Contract

Caro, P.W. Some Factors Influencing Air Force Simulator Training Effectiveness. Technical Report 77-2. Human Resources Research Organization, Alexandria, Va., March 1977.

Caro, P.W. Some Current Problems in Simulator Design, Testing and Use. Professional Paper 2-77. Human Resources Research Organization, Alexandria, Va., March 1977.

Additional Reference

Caro, P.W. Platform Motion and Simulator Training Effectiveness. Paper submitted to 10th Naval Training Equipment Center/Industry Conference, November, 1977.

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) <p>This is the final report of Contract No. F44620-76-C-0118. The purpose of the research was to gain a better understanding of how simulator training might be made more effective in the U.S. Air Force. The report briefly summarizes the activities of the research project and identifies the two technical reports and one conference paper prepared during the project. The reports and paper are also summarized, and the principal findings and conclusions of the research are described. This report contains no significant information not contained in the two project technical reports.</p>			